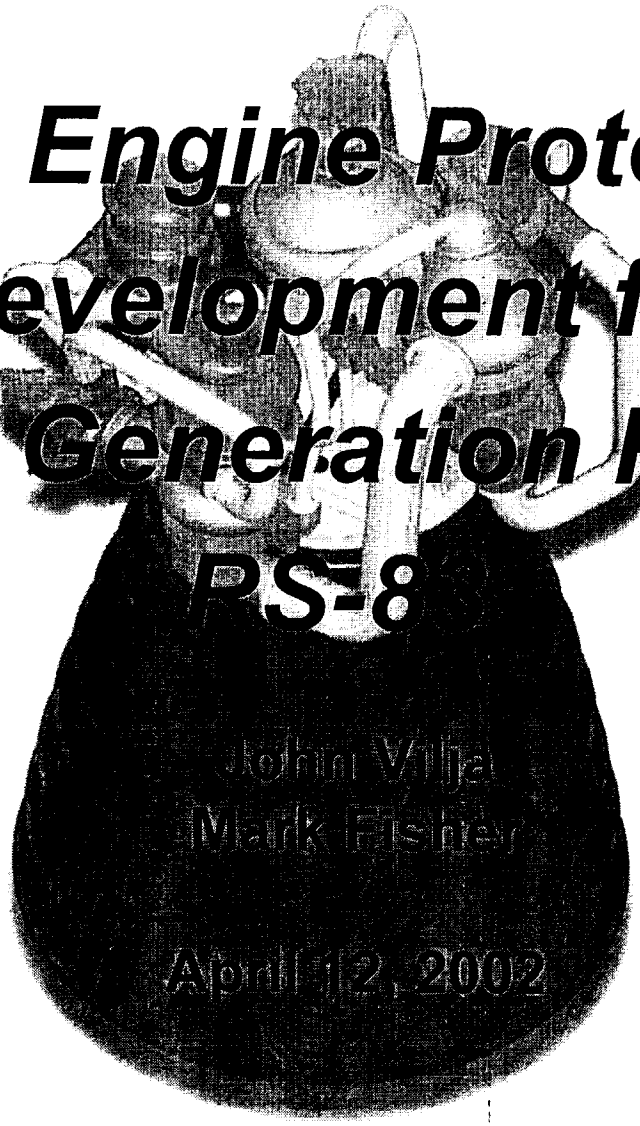
Main Engine Prototype Development for 2nd Generation RLV RS-83



John Vilja
Mark Fisher

April 12, 2002

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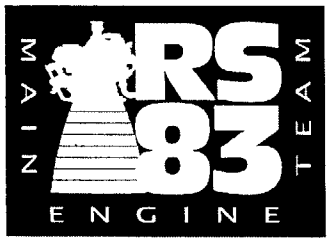

Program Objectives

- Retire risks for a 2nd Generation Reusable Engine
  - All technologies demonstrated in prototype
  - Build to most challenging conditions
    - Component operation (e.g. combustion stability)
    - Manufacturing capability (e.g. forgings)
  - Enable commercial engine viability

- Work to requirements flowed to engine from program
  - Loss of crew 1 in 10,000
  - Loss of vehicle 1 in 1,000
  - $1000/lb to LEO

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Propulsion & Power

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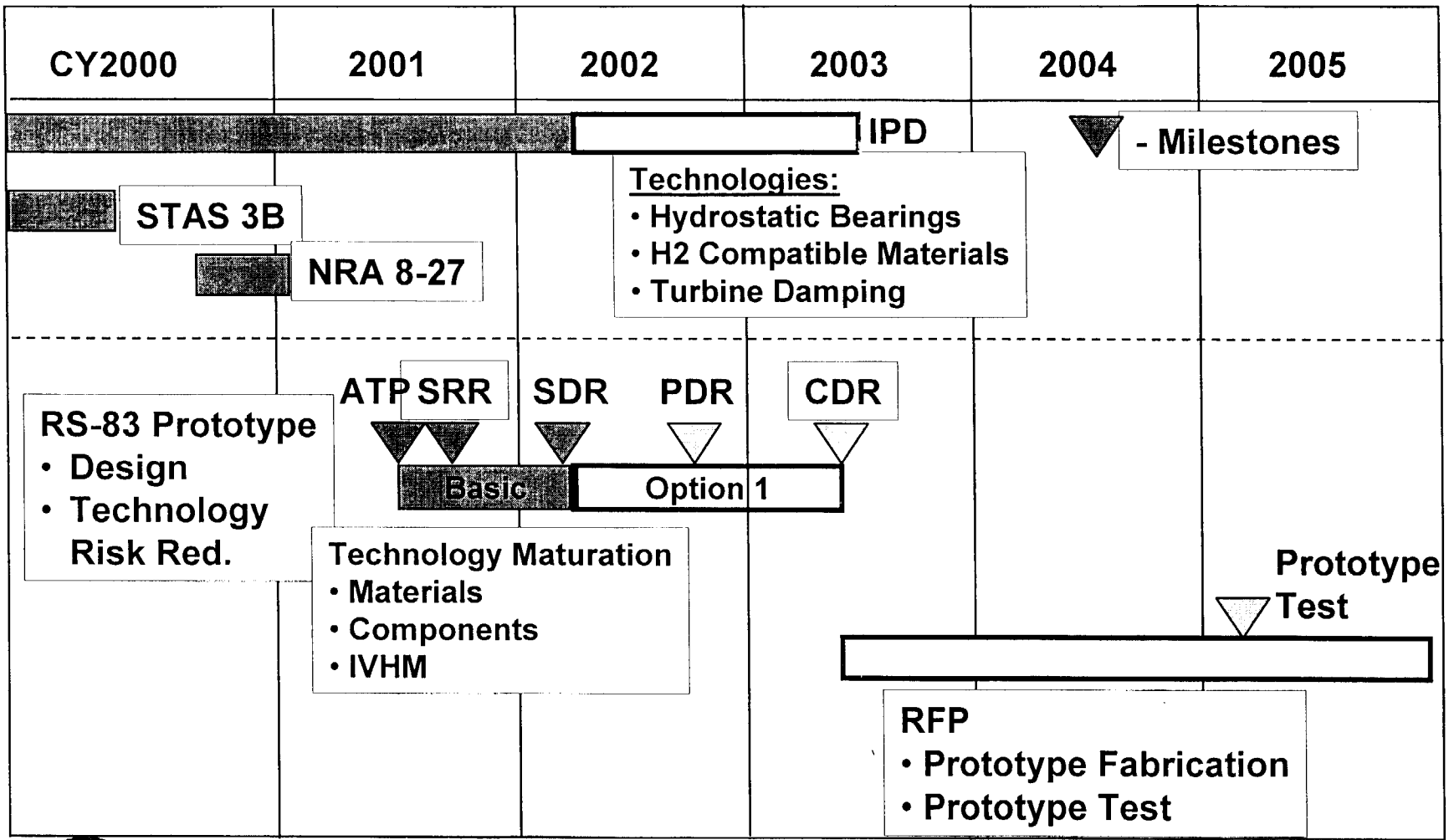
Overview Schedule



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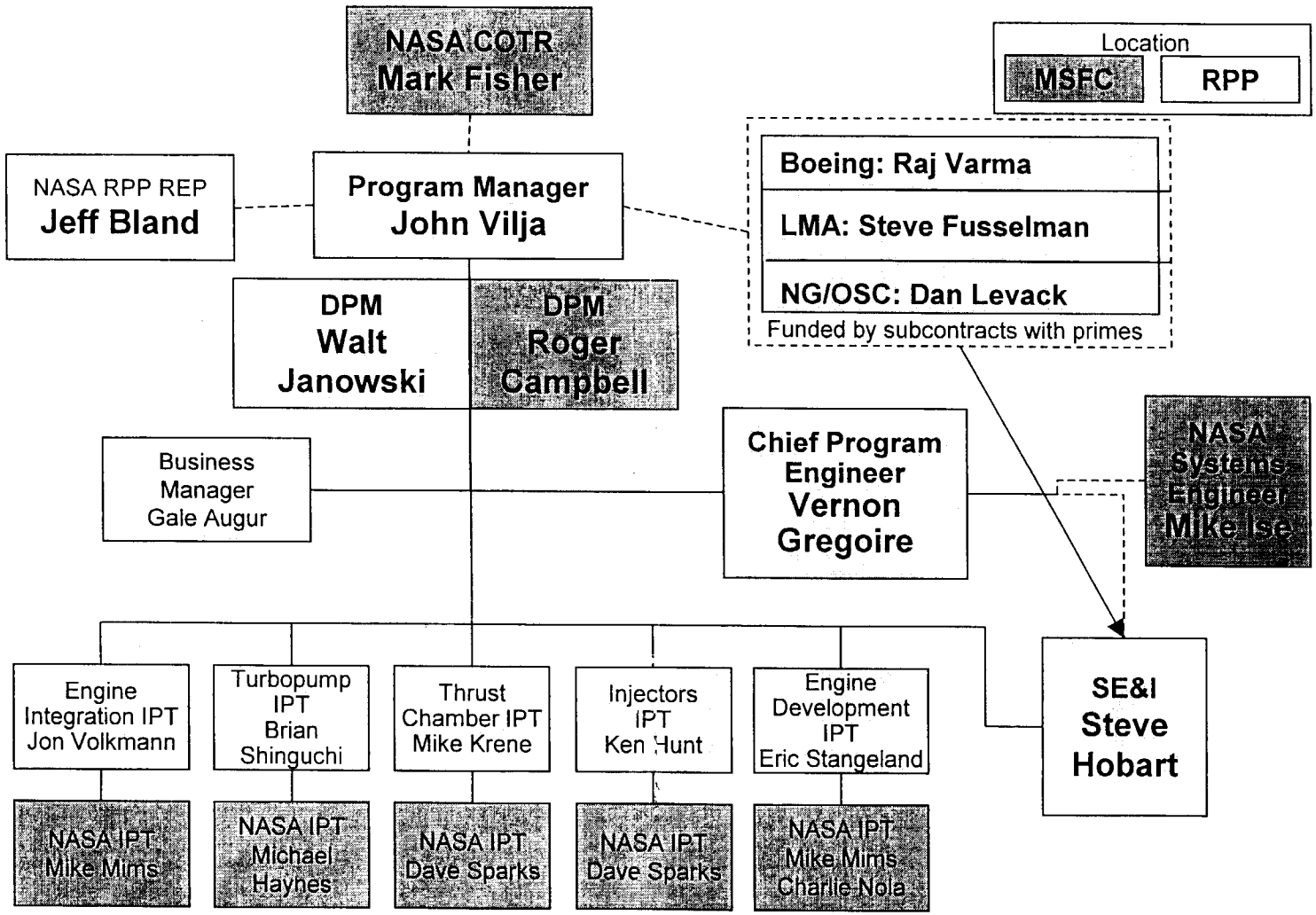
RS-83 Management Team



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Team has Recent Rocket Engine Development Experience

SSME Block II

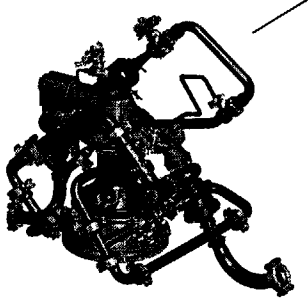
RS-68

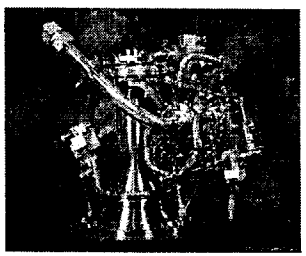
XRS-2200

RS-83 Team

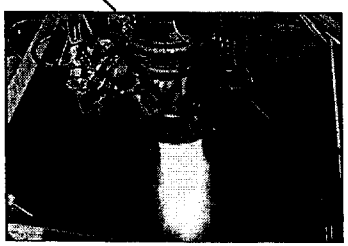
Fastrac/MC-1

IPD





RS-72



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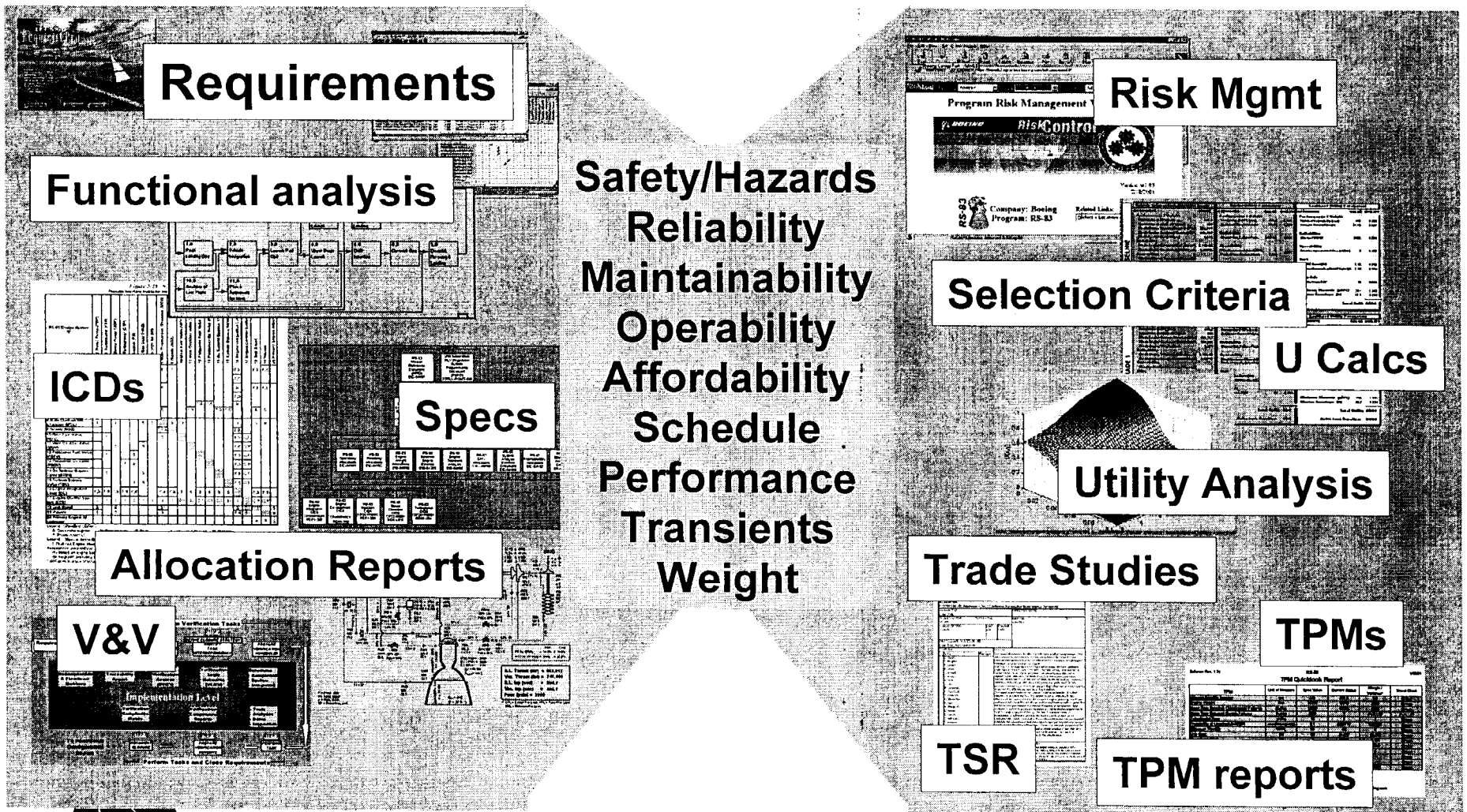
Integrated Systems Engineering Processes



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Requirement Analysis and Development

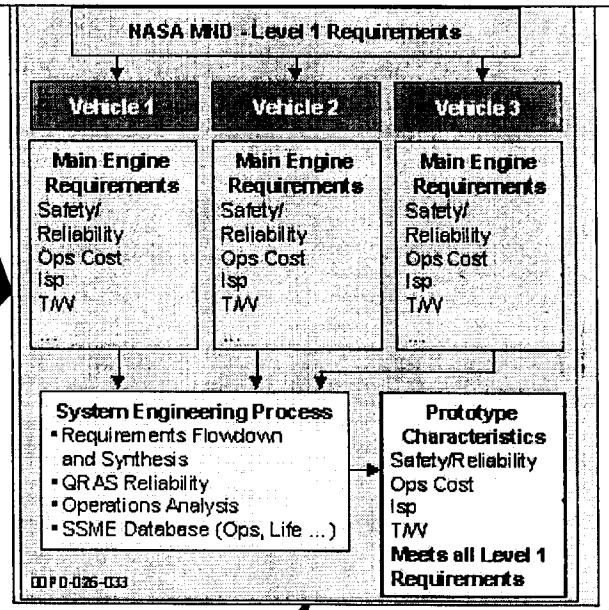
RS 83 MAIN ENGINE TEAM

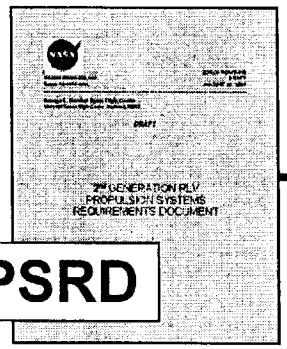
Reqts Synthesis for Risk Reduction Prototype

NRA 8-27 (Vehicle Reqts)

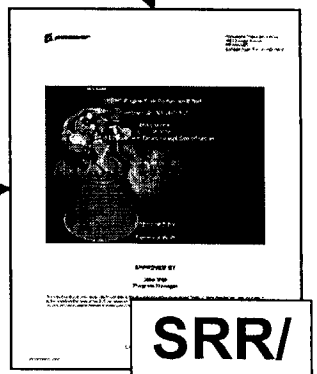
Additional Vehicle Reqts

Proposed Engine





PSRD



SRR/ PIDS

Conceptual Development

- Reqts Allocations
- Component Limits
- Trade Studies
- Utility Analysis
- Engine Balance

Derived Reqts

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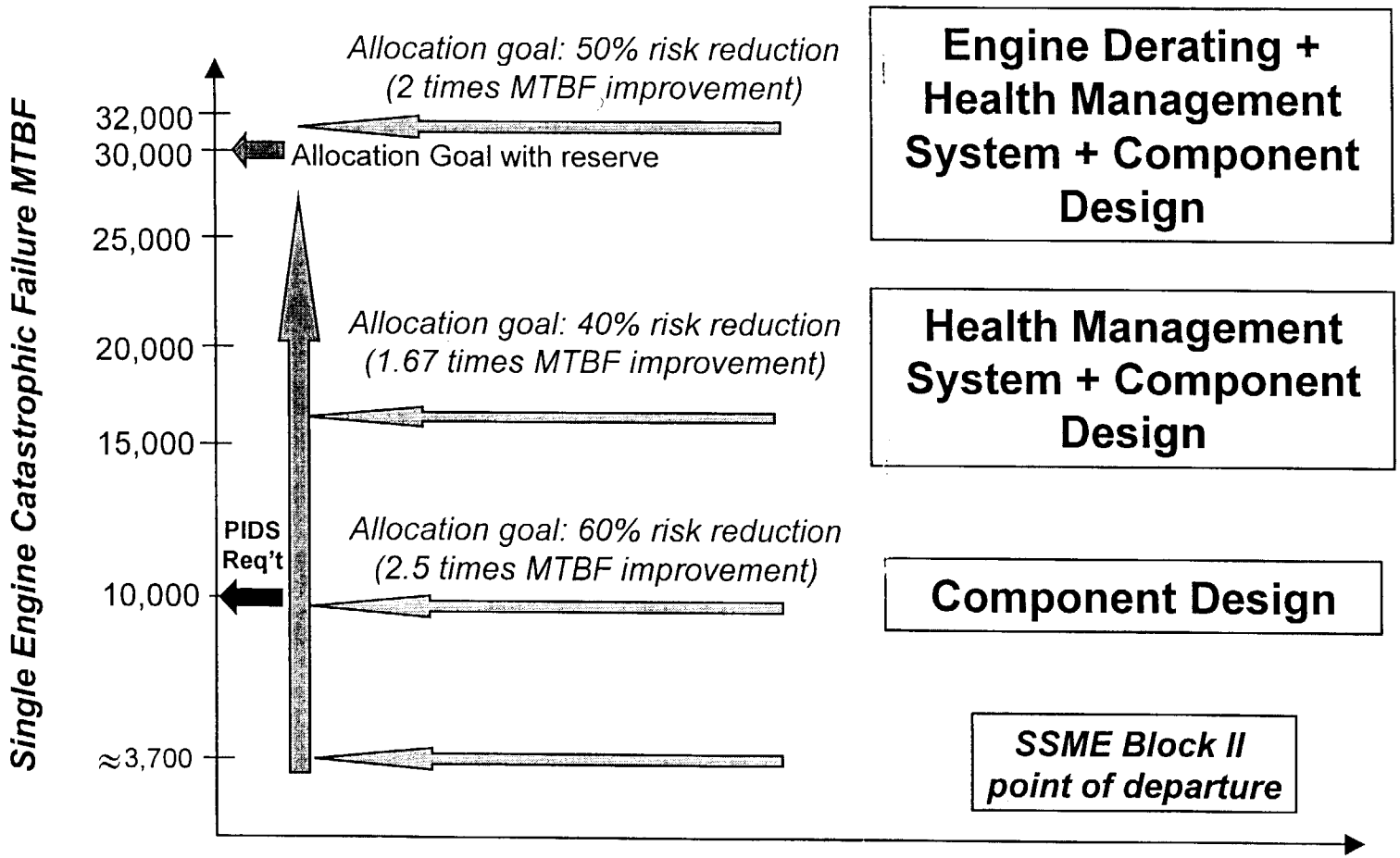
Catastrophic Loss of Engine

Allocation to Subsystems and Component Teams



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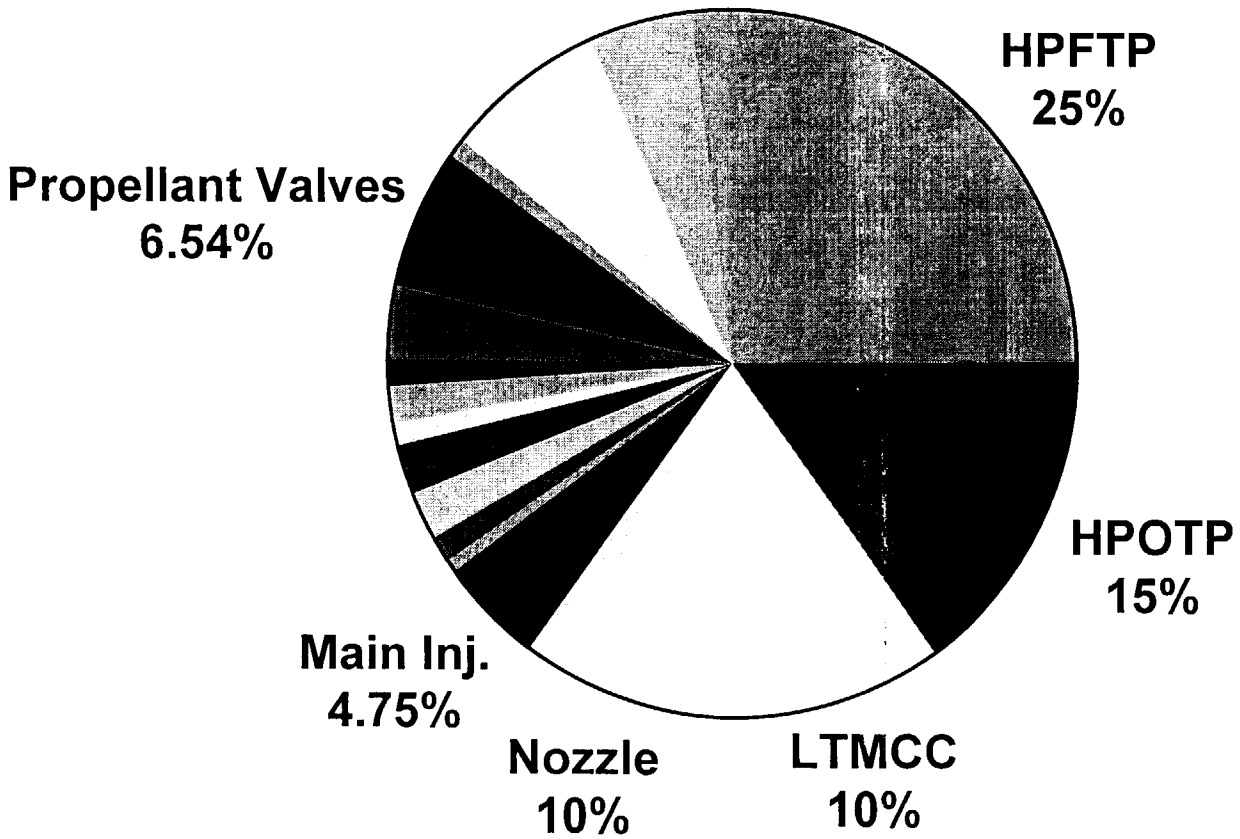
SSME Block II Failure Probability by Component



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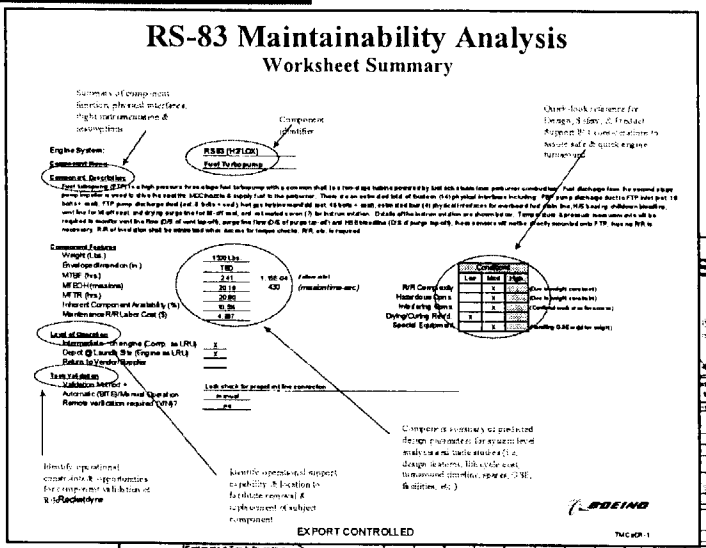
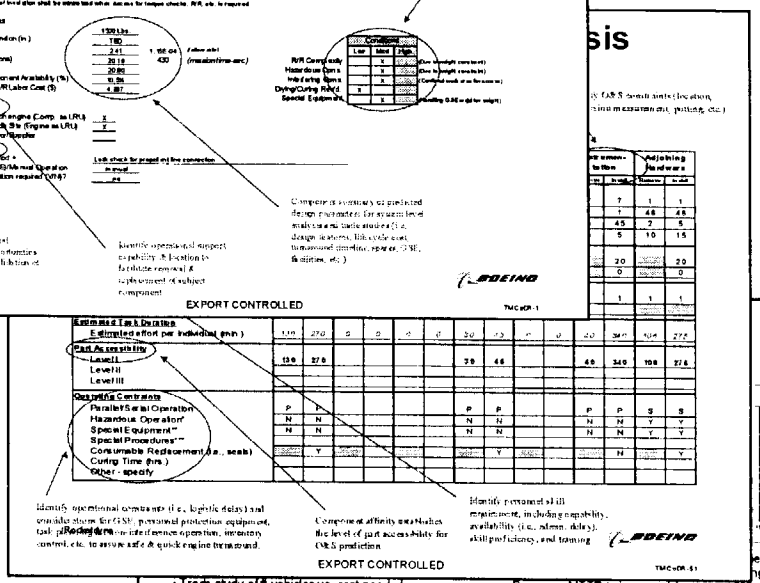
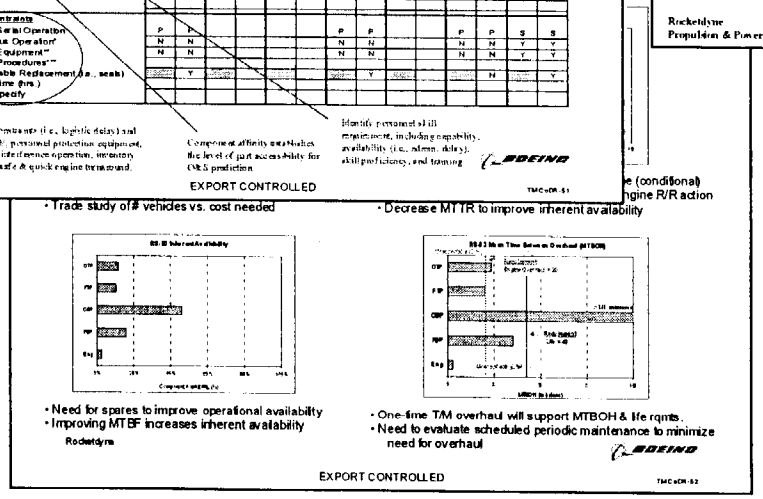
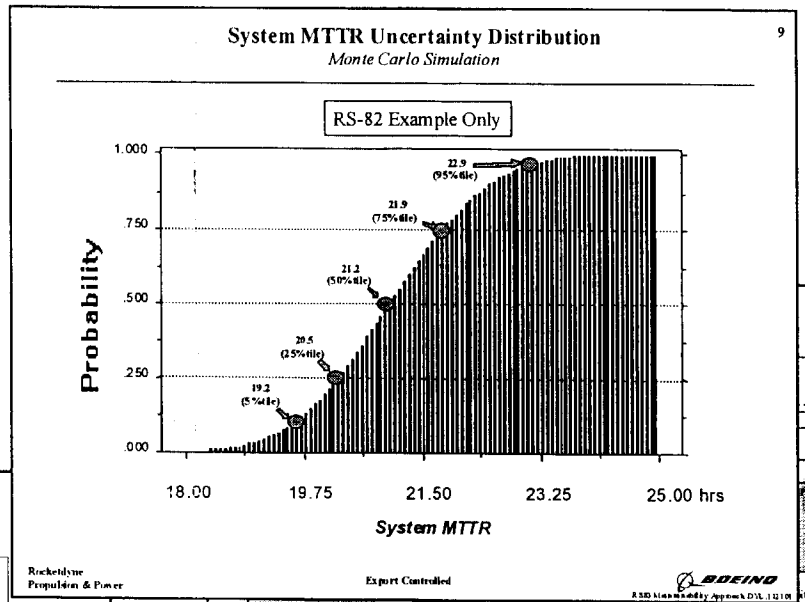
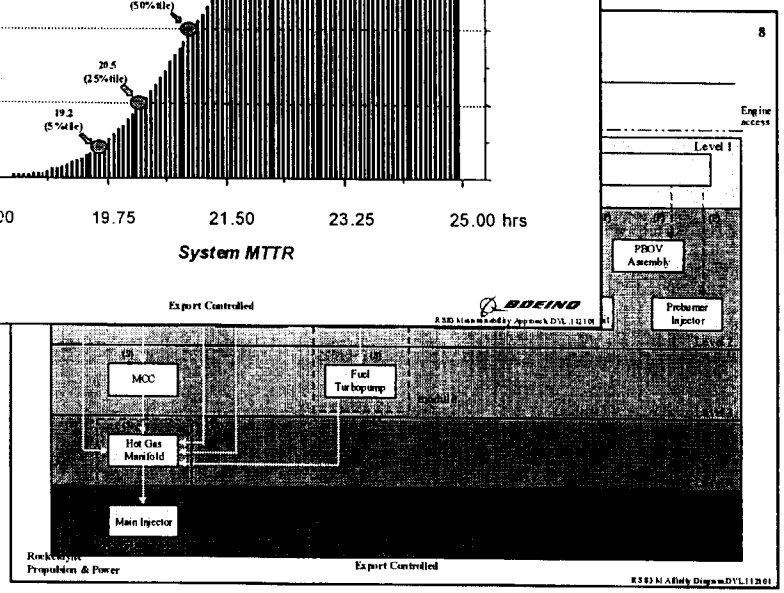
Maintainability Analysis Tools











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Utility-Based Trade Methodology
System-Level Trades

Traded Options

- Reference Configuration
- Viable Option 1
- Viable Option 2
- Viable Option 3

Option Assessment with respect to Decision Attributes

- Isp
- Weight
- Cost
- Reliability
- Safety
- Operability
- Risk

BASELINE

Vehicle Iridependent Attribute Inputs

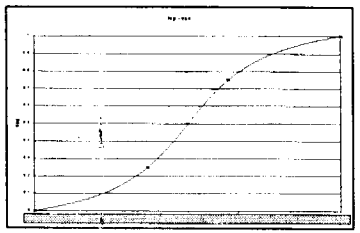
ATTRIBUTE	VALUE
Performance / Weight	
Vacuum Isp @ RPL (sec)	447.5
Vacuum Isp @ nominal PL (sec)	447
Single Engine Vacuum Thrust @ RPL (lbf)	751,717
Single Engine Sea Level Thrust @ RPL (lbf)	650,000
Single Engine Weight (lbm)	10,513
Reliability	
Single Engine Catastrophic Failure Prob.	5.187E-05
Single Engine Unscheduled R&R Prob.	0.0831788
Operability	
4 Engine Cluster Turnaround Time (shifts)	7
Cost	
Development Cost ($M)	
Boeing Unit Cost ($M)	
Lockheed Unit Cost ($M)	
Schedule	
Months from PDR to 1st flight set delivery	66
Throttle	
Minimum Throttle (%RPL)	50%
Envelope	
Nozzle Exit O.D. (inches)	96

Translate Assessment into Figures of Merit

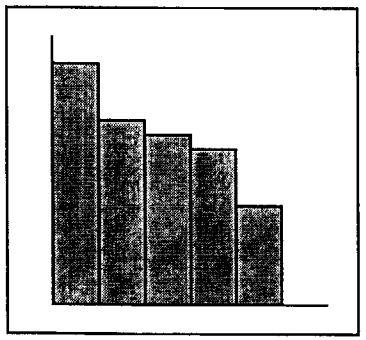
Sensitivities

On Select trades

Utilities



Determine Overall Rankings



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RS-83 Designs in High Reliability and Cost Reduction

- Series turbines
  - Eliminate potential for "Run Away"
  - Higher efficiency reduce turbine temp
- Reduced turbine temperature
  - Improve turbine life
  - Eliminate hot-gas duct cooling
- Liquid/Liquid Preburners
  - Eliminates turbine temp spikes
- Turbopumps
  - Achieve long life by eliminating rolling element bearings
  - Incorporate Hydrostatic bearings
- Hydrogen compatible materials
  - Eliminate reliability, cost, and maintenance issues with plating
  - Powder metal enables large parts

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RS-83 Prototype Engine

- **Thrust**
  - Sea Level 664 klb
  - Vacuum 750 klb
- **Specific Impulse**
  - Sea Level 395 sec.
  - Vacuum 446 sec.
- **Weight** 12,700 lbm
- **Life** 100 Missions
- **Dimensions**
  - Length 171 in.
  - Diameter 115 in.
- **Demonstrates all candidate technologies for FSD engine**

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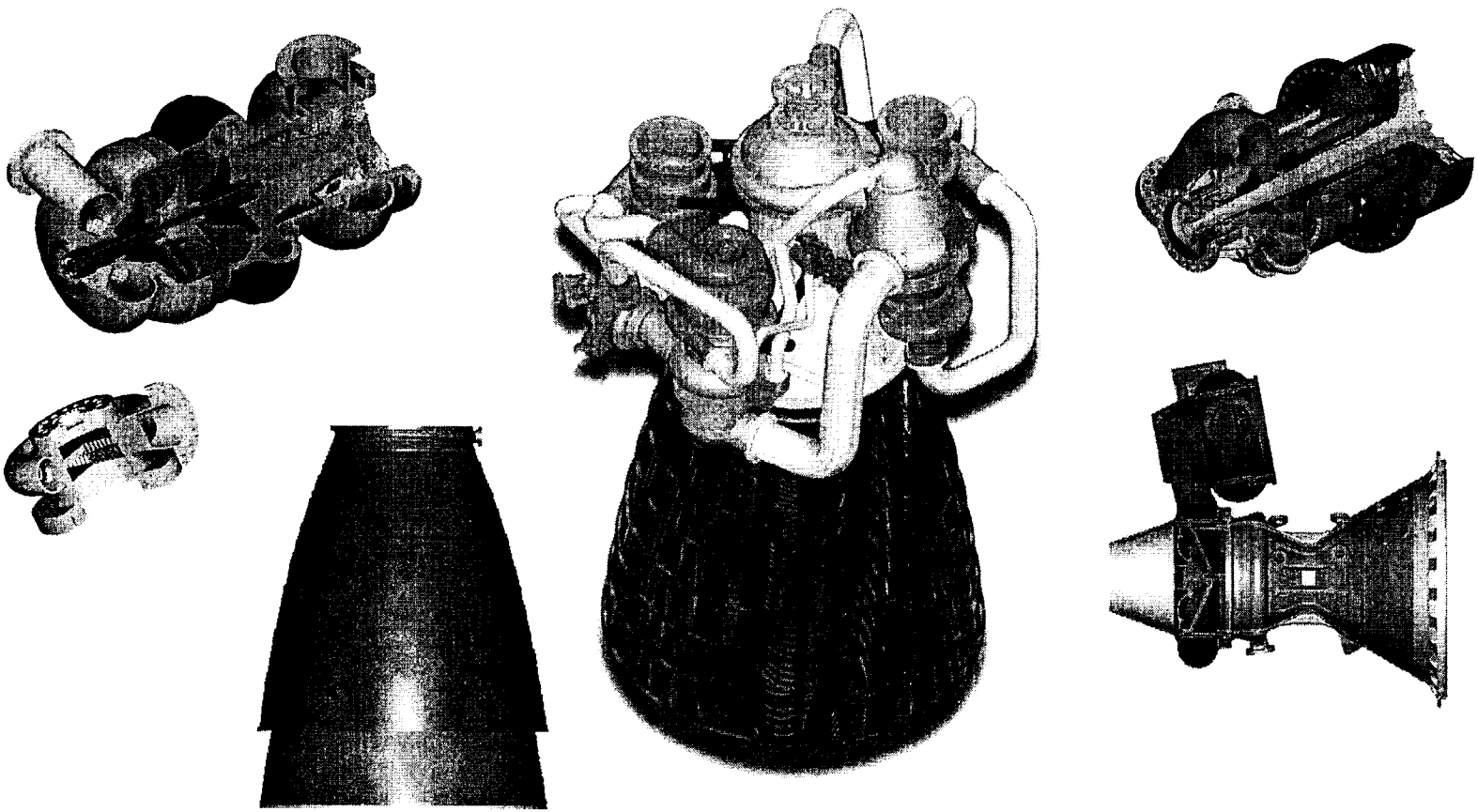
Designs Maturing Rapidly



CoDR completed on all major parts

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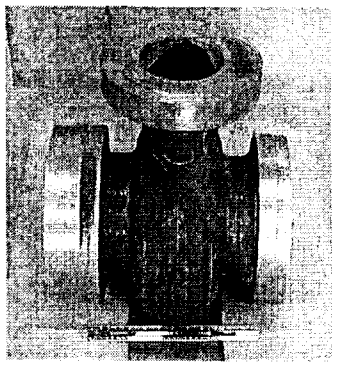
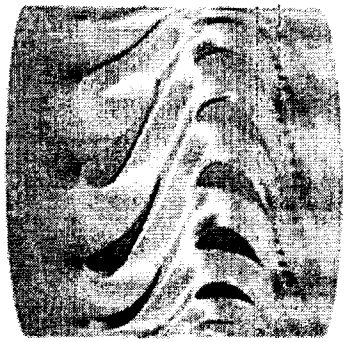
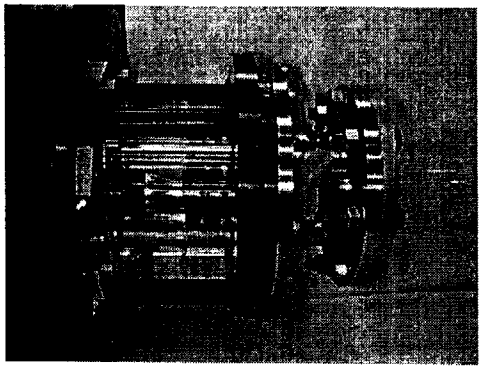
Key Risk Mitigation Tests in Work



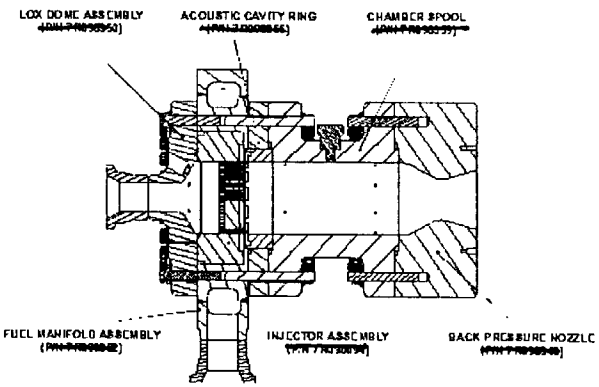
Advanced Mat'ls & Processes



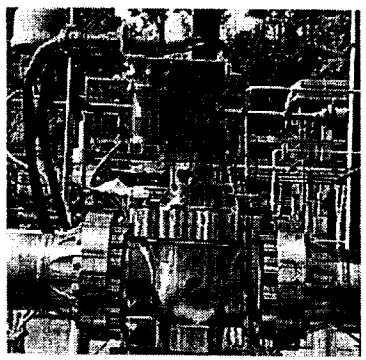
Model Correlation



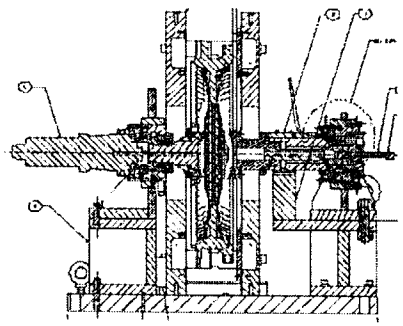
Flow Characterization



Component Demo



Component Characterization



Technology Evaluation

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Summary

- RS-83 engine meets all SLI requirements with margin
- Project is on budget & schedule
- High performance NASA/contractor team in-place
- Trades based on rigorous systems engineering processes
- CoDRs conducted for Turbopumps and Combustion Devices
- Early retirement of key risks taking place
- Communication within team enhanced by web-based information technology
- All elements in-place to assure success

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